Spanish Association of Astronomical Spectroscopy

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Spectral Study of Comet Lovejoy C Q2 2014

A. L. Calvente Ortiz

alfonso@espectrografia.es

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SUMMARY: Using the spectrograph DADOS with 200 l / mm and 900 l / mm grattings at home observatory of Tejina (C11), Tenerife, we obtained the visual spectrum of Comet Lovejoy at their point of closest approach to Earth. Spectral analysis allows us to cover a range between 3800 and 7500 Å. We have compared our results with the work on other comets, allowing positive identification of the elements and molecules found and has also opened up the possibility of comparatively analyzing the structure and composition of C 2014 Q2.

1. Introduction

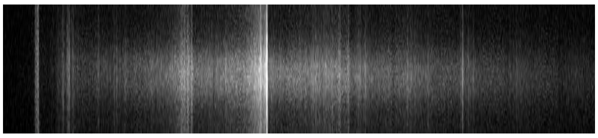
The astronomical spectroscopy allows chemical and structural study of comets. Comets are chunks of ice itself and dust residues originating disk of dust and gas from which our solar system was formed. The study of comets is of great interest not only from the perspective of a deeper understanding of planetary formation processes of knowledge, also for the study and identification of these molecular complexes that hold biological structures of live and that one day they landed on our planet possibly through cometary impacts.

Spectroscopic analysis provides us with information that surrounds and the comma following the comet nucleus. Approaching the sun, the core substances sublime (go directly from solid to gas) due to the effects of a quick rise in temperature produced by solar radiation, this process produces spectrally countless emission lines corresponding to different molecules and chemicals involved in the process and came entirely from the cometary nucleus.

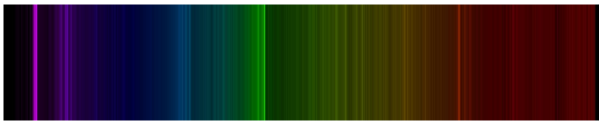
In the visible spectrum, which is the wavelength range in which we work, in addition to the effects of atomic and molecular emission analyzed, we can observe the spectrum of sunlight that is reflected on the comet. This allows to study the envelope of dust and gas that surrounds and accompanies the comet and will present different absorption lines of the solar spectrum.

2. The spectrum of 200 l / mm 2014 C Q2.

The spectrum obtained from the observatory at Tejina (Tenerife) was composed by a single wall made on a C11 300seg tube with a Atik 314L + (binx2) through a spectrograph DADOS 200 l/ mm (15/01/14, 23:40).



Spectrum 200 l/mm C 2014 Q2



Color sinthesized spectrum 200l/mm C2014 Q2

The spectrum of 200 l / mm shows a range between 3785 and 7160 Å.

The raw spectrum shows a high intensity continium that corresponds to the core region of the comet, loses strength towards the ultraviolet and infrared. The strong emission lines correspond to the CN (cyanide) in the violet and C_2 (Carbon diatomic) in green, somewhat attenuated the issuance of NH_2 (dihydride Nitrogen - amine group) appears in red. Check the intensity of emission lines are going dissipating a greater or lesser degree depending we move away from core (in this case this distance corresponds to the top and bottom of the raw image in which the continuous and disappears), this emission can be observed even also quite far from the nucleus, and in the part of the comet's tail.

The distribution of the main lines is typical of the spectra obtained in other comets. The abundance of the identified elements is characteristic of many comets with which we visually compared the spectrum obtained. Not so much the lack of resolution as limiting the wavelength range studied, we prevent identification of the different molecules that can be found in the dust that is part of the cometary coma. We must be content with the limited analysis of the radicals identified in the visual spectrum.

Even with these limitations, we can sense the abundance of elements such as HCN, C2H2, C2H6 and NH3, every time that these same in the sublimation process produced by photo-dissociation those. These elements produce the radicals mentioned identified among the following:

HCN >> CN

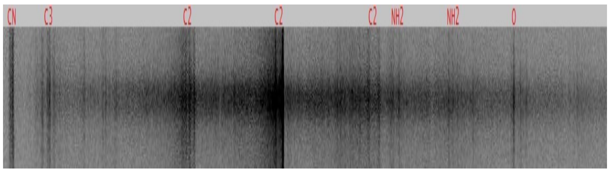
C2H2 >> C2

C2H6 >> C2

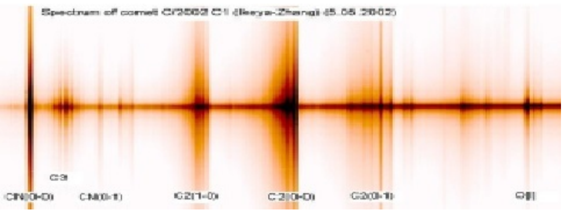
NH3 >> NH2

To detect directly the original (and even some of the aforementioned radicals) molecules should work with radio waves or infrared and ultraviolet spectroscopy, which cover wavelengths where the detection of molecular emission lines is possible.

Still very interesting analysis that can make our means. A comparison of our spectrum with the spectrum of other comets shows that both the composition and processes that are triggered in their approaches to the sun are similar:



Spectrum 200 l/mm C 2014 Q2. AESESAS,2015

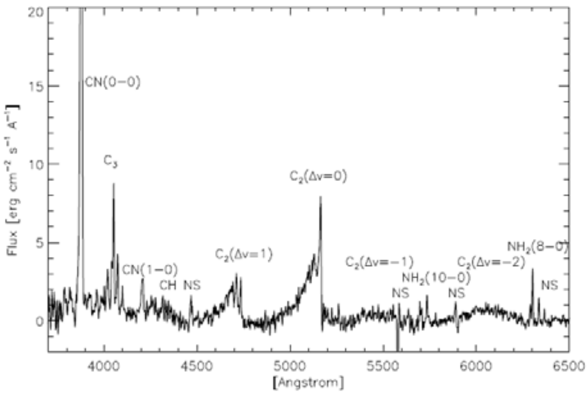


C/2002 C1 (Ikeya-Zhang)

We can see how the emission lines of comet C / 2002 C1 (Ikeya-Zhang) coincide dramatically with those observed in our spectrum of Comet C / 2014 Q2 (Lovejoy).

The spectrographic analysis will allow us to identify each of the lines giving us unambiguous information on the structural composition of the core and the cloud of dust and gas that surrounds it.

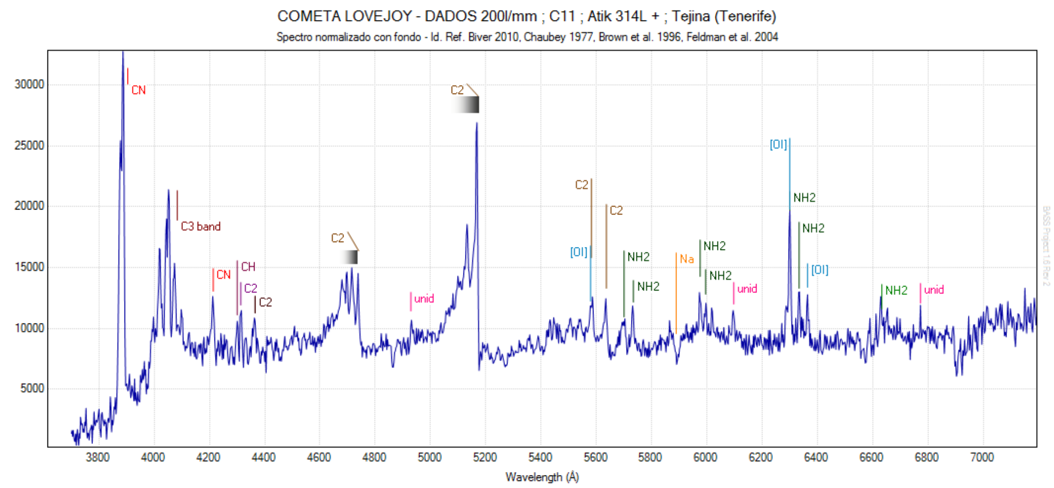
The chart shown below presents the spectrum of Comet C / 1995 O1 (Hale-Bopp) obtained with the 1.5 m telescope. ESO in 1997. In addition to checking the same spectral distribution, surprising detail achieved with our little humble C11 and our means against the spectrum shown in the graph.



Comet C/1995 O1 (Hale-Bopp) Tel. 1,5 m. ESO 1997

A identical distribution of identified lines (more and in greater detail in our graph shown below) and matched well with the spectrum of Ikeya Zhang corroborate the common origin of these stellar objects by way of comets appear to us so close to our planet. The great cloud of Orts that surrounds our planetary system is undoubtedly a remnant of that primigenioo material that was formed our solar system.

The influence of gravitational and tidal forces, proximity or even the impact of other moving objects and can catapult new pieces of "cosmic ice" to the center of our planetary system leading to new observable comets. They keep the same general features but a deeper study of them contributes and will continue to provide important information on the processes of planet formation and even molecular structure that underpins life itself.



In our spectrum at 200 l / mm we have successfully identified a total of seven elements and substances:

O I: this has nothing to do with atmospheric oxygen O2 identified that exhibits strong absorption lines in the lengths of λ = 6276-6287; 6867-6884; 7594-7621 Å.

Emission lines are identified within those calls forbidden transitions (only seen in some processed or molecular decomposition). In our case OI lines identified are:

λ = 6300.304 Å >> ^1D-^3P; in red

λ = 6363.776 Å >> ^1D-^3P; in red

λ = 5577.339 Å >> ^1S-^1D; in green

Oxygen responsible for emissions has been formed by different processes of decomposition of the nucleus molecules and fall off it. The original molecules are mainly H2O and CO and CO2. Other molecules that can undergo similar processes, such as HCOOH and H2CO not seem to be responsible for the OI resultant-gotten accounts that the latter do not suffer degradation fast enough to produce the transition observed in the O (^1D).

Na: In our spectrum of 200 l / mm, the reflection on Lovejoy surface of sunlight is the responsable of sodium absortion line the surface of Lovejoy. Absorption is referred to respond to the solar Na placing absocion strong doublet at λ = λ = 5889.95 and 5895.92 lines, which the resolution of our spectrograph shown as a single strong and broad absorption line. Perhaps higher resolution we can identify the issue that has been observed in other comets.

C2: two major bands found emission C2: 4737Å (-20nm) and 5165Å (-30nm). These emission bands can be found far from the nucleus, in the far tail of the comet, which implies a high production of this item.

The C2 is straightforward, mainly from C2H, which in turn comes from the decomposition of C2H2 product.

C3: The instability of this molecule difficult to study by the lack of experimental laboratory observations. Find a remarkable group between 3900 and 4140 Å, and although the density C3 lines make it very difficult to individualize, can find him lines attributable to 4700 Å.

The process leading to C3 is actually unknown. Chemically it is possible that its origin is due to the decomposition of C3H4 and C3H8, but these molecules have been detected in cometary spectra.

CN: In our visual spectrum are two CN emission bands, one of great intensity although short in 3883 Å (-4nm), and a short and very intense in 4215 Å (-4nm).

The element that potentially gives rise to CN is yes HCN has been observed in the infrared, but you can not know for sure if it is the main producer or a secondary one.

Festou et al (1998) concluded that seems consistent to think that the main producer of CN is the C2N2.

CH: CH has its emission peak at the 4314 Å. Its stability 1HU is very short and can range from 35-315 sec. until it is decomposed by photo-dissociation.

Probably its origin is in the CH4. Methane first decay in CH2 and then east on CH.

There is an emission line at 3886 Å but you can not isolate the CN at low resolution.

NH2: The NH2 from the decomposition of NH3 (newly detected radio wave). NH NH2 decay which is detectable in the ultraviolet.

Nicolas Biver (Cometary Spectroscopy) presents the main lines of NH 2: 515, 545, 600, 630, 665, 695 and 735 nm. The heaviest have been identified in our spectrum.

3. The line 4133 of Bobronikoff.

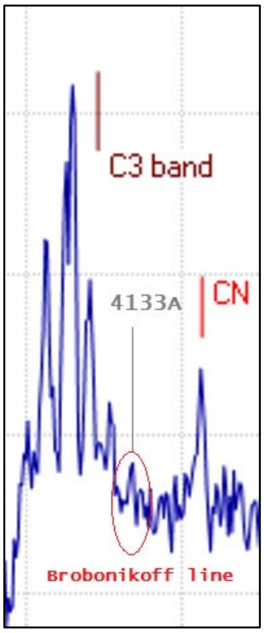
In 1925, from the Royal Observatory of Catania Italiano, NT Brovonikoff takes seven shots ultraviolet camera. It is they pointed to the comet Temple-2, which achieves a visual magnitude of 9. There were seven shots with exposure times of 30-230 minutes. Brovonikoff identify the "Cyanogen" to 3883 Å, Carbon Monoxide (CO) at 4355, 4722 and 4919, and two lines for him unidentified 4133 Å and 4591 Å.

4591 Å line has subsequently been identified as among the comet C2 components, emitting at this wavelength (4590.95 Å) at the transition (2,1) R1 (61) + R2 (60).

However the 4133 Å line does not appear in the "Catalogue of High Resolution cometary emission lines" published by the "Astronomical Journal" (112, 1197-1202, 1996), which was made by ME Brown, A.H. Bouchez, H. Spinrad, and C. M. Johns-Krull.

The nearest known lines can not cause confusion since they are in 4100.30 Å (C3) and 4182.21 Å (CN). This line is not observed in the spectrum of Halley-Bopp although it seems to have formed in the spectrum of Ikeya-Zhang.

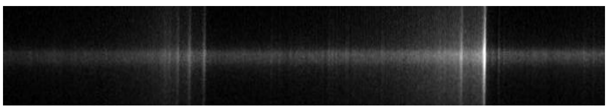
Anyway, among all the literature and consultation work we found no reference to this line or any nearby with which it might be confused. Our concern is that if on the Lovejoy. There is a line of great intensity but it is observable in the spectrum:



In the detail of our spectrum Brobonikoff note that the line is followed by a line relative absorption, possibly the result of sunlight reflected on the comet, and would correspond to unconjunto absorption lines where the predominant Fe I between 4132 and 4135 Å.

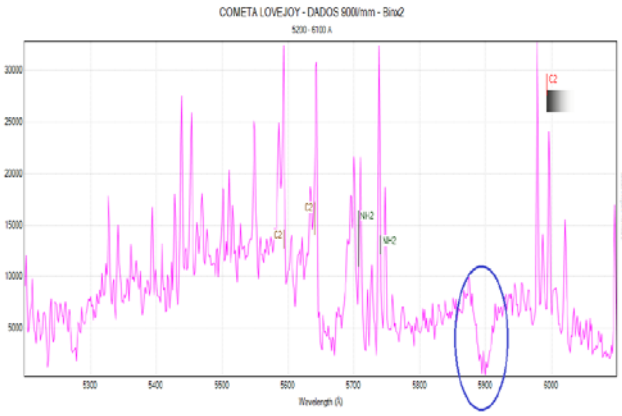
4. Spectrum 900 l / mm.

The spectrum obtained with the spectrograph DICE with "gratting 900 l / mm", the C11 tube and ccd Atik 314L +, has not allowed us a big difference in the final outcome, since we use the "ccd" with the option binx2 limiting the maximum R achievable with this grid.



Espectro a 900 l/mm en el area de 5900-6800 Å. La fuerte línea de emisión de la derecha corresponde al O I.

Perhaps the most revealing fact, besides the splitting of multiple lines and identifying new series of C2 emission is possible that there seems to be at the center of the absorption line of Na.



Spectrum 900 l/mm. 5200-6100 Å

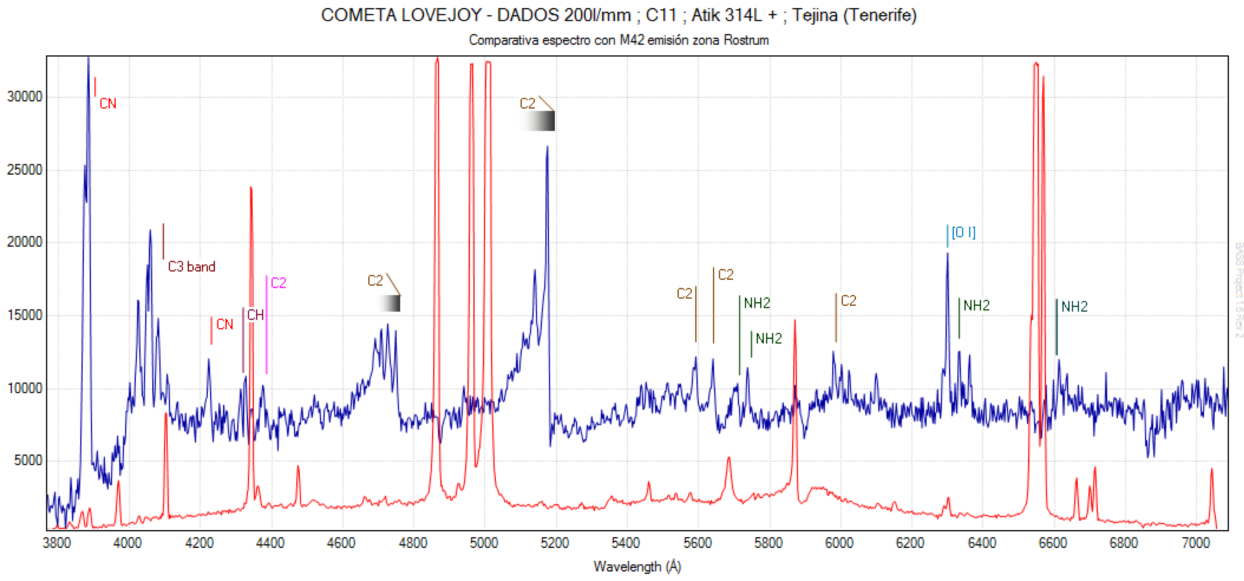
5. Elements to be identified.

As reference for future studies, and to confirm the importance of the study of comets has to understand not only the formation of our solar system, but to decipher the processes of molecular formation culminating developing all molecular structures that it uses life for sustenance.

Huebner et al (Heat and Gas Diffusion in Comet Nuclei, 2006), shown in a comparison with the elements and molecules identified in the interstellar medium a list of those who have come to be identified in different comets and their structures:

CH	NH
OH	C2
CN	CO
N2	CS
NS	NO
N2	CH2
H2S	C3
CO2	OCS
SO2	CS2
NH3	HC2H
H2CO	HNCO
H2CS	C2H6
CH3OCHO	OH(CH)2OH
NH2	H20
C2H	HCN
HN	HCO
CH4	HCOOH
C4H	HC3N
CH3OH	CH3CH
CHCHO	NH2CHO

Comparative spectroscopy with Orion Nebula:

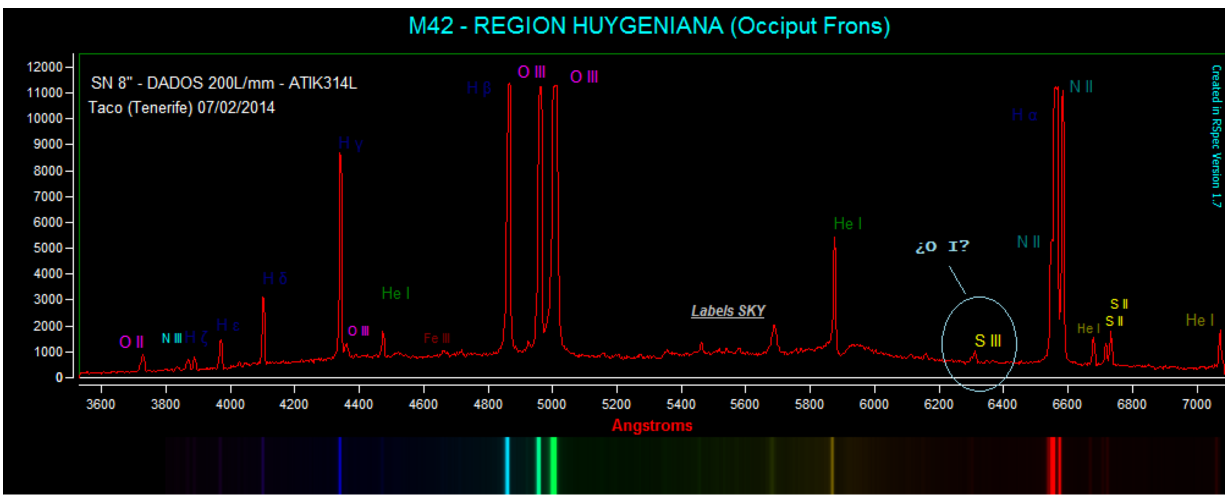


Comet Lovejoy (2015 – Blue) and M42 (2014 – Red)

In the graph we can see red spectrum of the Orion Nebula to the same resolution as the spectrum of Comet Lovejoy (in blue). It is evident that so very different spectra correspond to also completely different elements. The hydrogen cloud in which the stars in M42 are formed has a totally different molecular compounds that can identify a comet composition.

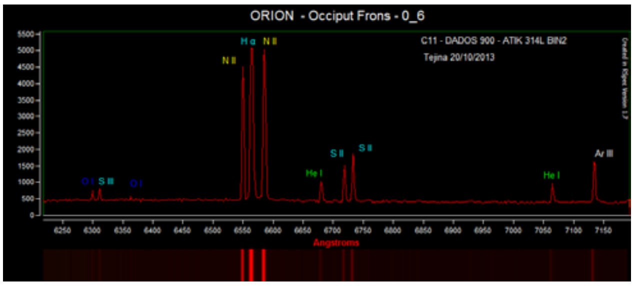
The spectrum of M42 and the spectrum of a comet show two different stages of the process of star formation. Shown in M42 we spectrum of an H II region of the cloud affected by radiation from nearby young stars that cause ionization of different nebular elements, which allows us to identification by spectral emission in the visual. The gas we observe, then, is the same compound (region HI) who participated in training (accretion) of young stars surrounding, only now this gas been radiated and ionized significantly increasing its temperature which prevents, in that place new processes nebular collapse and accretion.

On the other hand the spectrum of the comet shows the remaining compounds the end of the star formation process, ie we are in the before and after a process of star formation that runs over a period that varies depending on the size star on a scale ranging from 10 to 10 ³ million years.



M42 spectrums with 200 y 900 l/mm DADOS done at 2014 by Calvente, Zumaquero et Sosa.

Despite not find, in general, any correlation between the lines observed in the spectrum of Lovejoy and M42 (a line coinciding appearance differs higher resolution, as He I emission in M42 at 5876 Å that is different to that found Lovejoy at 5874.56 Å corresponding to the emission of C2), we find S III emission in M42 with a very similar to the one identified as OI in Lovejoy contour.



Espectro de M42 obtenidas a 900 l/mm en 2014 por Calvente, Zumaquero y Sosa

However considering the higher resolution spectrum of M42 are actually the splitting line S III also identifies a OI emission being also in the spectrum we find a splitting comet NH2 with the peculiarity that in this case the OI emission is much more intense.

It is important that information which indicates that the processes leading to the issuance of OI (forbidden line) by dissociation of more complex molecules were present in the H II region and comets radiated by our sun. However while different molecules originating in each case the process of emission from ionized oxygen is the same (transitions electronos levels are the same).

Conclusions:

The media of today are arranged at the amateur level are really amazing. Not only in terms of tools and equipment with which to work in astronomy, and more specifically in astronomical spectroscopy, but also in a way unimaginable for a scientist fifty years with regard to access to specialized documentation libraries, databases, experimental simulation programs and catalogs.

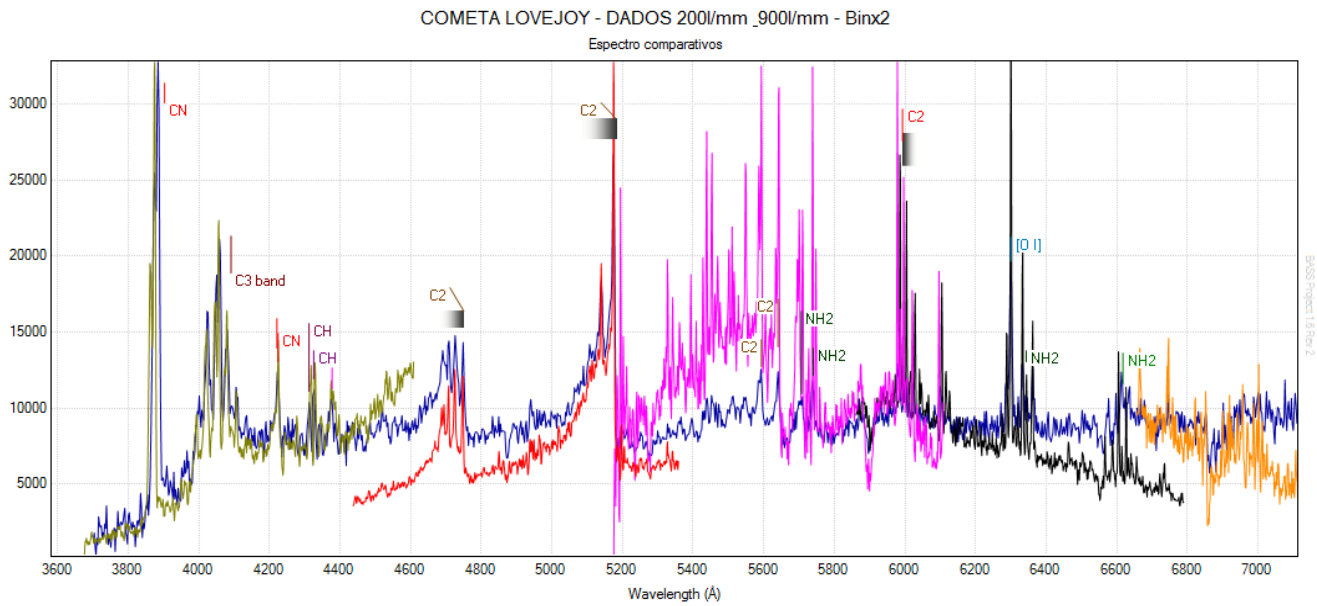
All this makes our task amateur simple, an exciting trip to the intricacies of cutting-edge science spectrograph.

We have checked with our own means as comets are carriers of complex molecules that constitute the fundamental building blocks of the building of life for their livelihood uses.

The discusivo study on the identification of emission lines opens the door for further study of comets, their classification, and why not, in the identification of new lines and elements such as open question Bobronikoff line.

The actual magnitude of comets for the spectrographic technique is much less than the visual as this decreases to disregard the brightness of the entire object but the line or points of light from which it obtains the spectrum. That will force us in other studies to make presentations more time we can provide light spectra at high resolution.

The first brick is laid. It will be interesting to continue comparative studies with interstellar medium, accretion disks, protostars, protoplanetary disks and laboratory studies to continue watching the hands weaving life.



Comparative spectrums. Comet Lovejoy at 900 l/mm (colors) on 200 l/mm in blue.

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